This Document
Reproduced From
Best Available Copy

AD A030892

12

DRSAR/SA/N-54

SYSTEMS ANALYSIS DIRECTORATE
ACTIVITIES SUMMARY
AUGUST 1976

SEPTEMBER 1976

Approved for public release; distribution unlimited.

US ARMY ARMAMENT COMMAND
SYSTEMS ANALYSIS DIRECTORATE
ROCK ISLAND, ILLINOIS 61201

DISPOSITION

Destroy this report when no longer needed. Do not return it to the originator.

DISCLAIMER

The findings in this report are not to be construed as an official Department of the Army position.

WARNING

Information and data contained in this document are based on input available at the time of preparation. Because the results may be subject to change, this document should not be construed to represent the official position of the US Army Development & Readiness Command unless so stated.

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER DRSAR/SA/N-54	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) SYSTEMS ANALYSIS DIRECTORATE ACTIVITIES SUMMARY. AUGUST 1976.		5. TYPE OF REPORT & PERIOD COVERED ~~6. PERFORMING ORG. REPORT NUMBER~~
7. AUTHOR(s) US Army Armament Command Systems Analysis Directorate (DRSAR-SA) Rock Island, IL 61201		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Command Systems Analysis Directorate (DRSAR-SA) Rock Island, IL 61201		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE 11 September 1976 13. NUMBER OF PAGES 68
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Muzzle Flash Detection	Biological Detector and Warning System, X19/XM2
Photopic Emissions	155mm Cannon Launched Guided Projectile
155mm Illuminating Projectile	COPPERHEAD
Laser-Target-Projectile Interface	HELLFIRE

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This monthly publication contains Memoranda for Record and other technical information that summarize the activities of the Systems Analysis Directorate, US Army Armament Command, Rock Island, IL.

The subjects dealt with are: Artillery Night Muzzle flash detection, 155mm illuminating projectile, Laser designator test standards, Biological detector and warning system, XM19/XM2; and 155mm cannon launched guided projectile (CLGP).

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

CONTENTS

	Page
Section I. GENERAL	5
Section II. MEMORANDA AND OTHER TECHNICAL INFORMATION	7
Algorithm for Estimating Detection Probabilities and Times for Muzzle Flashes at Night	9
Draft Letter of Agreement (LOA) for the Development of a 155mm Illuminating Projectile	29
Standards for Testing Laser Designators	37
Draft Test Design Plan (TDP) for DT II of the Biological Detector and Warning System, XM19/XM2	49
155mm Cannon Launched Guided Projectile (CLGP) Operational Analysis	55
DISTRIBUTION LIST	65

Next page is blank.

Section I. GENERAL

1. This monthly publication summarizes the activities of the Systems Analysis Directorate. The purpose of this note is to give wider and more timely distribution on subjects of concern to the command.

2. The most significant Memoranda for Record (MFR's) and other technical information will be published as notes or reports at a later date.

3. In order to assure accurate distribution of this publication, addition or deletion of addresses to/from the DISTRIBUTION LIST are invited and should be forwarded to the address below.

4. Inquiries applicable to specific items of interest may be forwarded to Commander, US Army Armament Command, ATTN: DRSAR-SA, Rock Island, IL 61201 (AUTOVON 793-4483/4628).

Next page is blank.

Section II. MEMORANDA AND OTHER TECHNICAL INFORMATION

Memoranda for Record and other technical information are grouped according to subject, where applicable, and in chronological order.

Next page is blank.

ALGORITHM FOR ESTIMATING DETECTION PROBABILITIES

AND TIMES FOR MUZZLE FLASHES AT NIGHT

Next page is blank.

DRSAR-SAM

1 JUL 1976

MEMORANDUM FOR RECORD

SUBJECT: Algorithm for Estimating Detection Probabilities and Times for Muzzle Flashes At Night

1. References:

a. Memorandum for Record, DRSAR-SAM, 19 Mar 76, subject: Study Plan for Vulnerability Assessment of the M110E2 Due to Muzzle Flash.

b. Interim Memo Report No 503, BRL, May 1976, title: Review of Study Plan for Vulnerability Assessment of the M110E2 Due to Muzzle Flash.

c. Technical Report No. AFATL-TR-75-74, JMEM, May 75, title: Summary of Electro-optical and Infrared Target Acquisition Field Test Data.

d. Mathematical Development of Algorithm on above subject (Incl 1 to MFR).

2. In Ref 1a and annexes the author discusses the need to quantify the process of detecting and locating the muzzle flash of artillery weapons. Detection of this signature is taken in the context of all other signatures suitable for locating artillery -- sound, radar, FM radio emission, and infrared. The BRL (Ref 1b) and other DOD agencies such as ECOM have been particularly concerned with the detection of infrared emission from the muzzle gases since the largest proportion of the total radiated energy falls above 0.7 μm wavelength -- typically, in excess of 99% -- and because of the presence of two good atmospheric transmission bands or "windows" in the infrared.

3. While it is natural to attempt to exploit the IR (and other) signatures of artillery targets and, therefore, to concentrate research attention on this topic, the fact remains that the human observer, with and without optical magnification, is still the most prevalent or common detection system currently in use on the battlefield. Therefore, it is of practical significance to describe the detection, acquisition, and recognition of targets -- during both day and night -- using only photopic emissions.

4. An extensive literature exists on detection and acquisition of targets during daylight conditions. Most field experiments and mathematical models apply to the case in which the target and surroundings, both of which are normally considered non-selfluminous, are illuminated by a common source of light, viz, the sun. In the case of acquisition (and recognition) of

targets during night- or low illumination conditions, the bulk of the literature concerns the effectiveness of the human assisted by electro-optical devices such as image intensifiers, low-light TV, infrared imaging systems, etc. A summary of a literature survey of pertinent tests is given in Ref 1c. In all of the above scenarios for target acquisition at night, the visual brightness of the target is negligibly small.

5. In Incl 1 to this MRF (Ref 1d) I am exclusively concerned about the detection of selfluminous targets under conditions in which the background has a brightness of 10^{-3} foot-lamberts or less ($3.4\ 10^{-3}$ candles/m^2). Parenthetically, it is noted that foveal detection under these conditions does not change much with diminishing background brightness below 10^{-3} foot-lamberts. The occurance of secondary muzzle flash in large caliber -- say, above 100mm -- guns produces a typical peak intensity of the order of 10^6 candles. This intensity varies by a factor of 2 or 3 from occasion to occasion and by a factor of about 10, depending on caliber and propelling charge. Over this range of intensities the flash constitutes a highly-detectable source. The apparent size of the source is quite sensitive to the charge mass. In the M107 SP howitzer, for example, the estimated maximum projected area of the source orthogonal to the direction of fire is about 100 m^2. The temporal persistence of the visual flash varies with the system and defining thresholds, and for the systems of interest varies from 30 to 300 millisec.

6. Detection of the above type of target at long range is in many respects similar to the astronomer's problem of detecting a faint celestial object. In fact, it may offer some insight to readers familiar with atronomical observation to compare the calculated visual magnitude of a flash with that of familiar heavenly bodies. By definition, the visual magnitude of a celestial object is given as

$$\text{vis mag} = 2.5 \log_{10} (E_o/E)$$

where E is the illuminance at the observer and E_o is a reference illuminance. In photometrically-equivalent radiometric units $E_o = 3.051\ 10^{-13}$ watts/cm^2. If the source intensity is given in photometric units -- say, candles -- the radiometric equivalent is given by:

$$\text{equivalent radiometric intensity (watts/str)} = \text{photometric intensity (candles)}/685$$

As a rule of thumb, an object of visual magnitude greater than about 5 is not detectable by the human eye.

MEMORANDUM FOR RECORD

SUBJECT: Algorithm for Estimating Detection Probabilities and Times for Muzzle Flashes At Night

7. The illuminance at range R from the source is calculated from the source intensity I and atmospheric transmissivity τ.

$$E = 10^{-10}\tau I/R^2,$$

where

$$\tau = \exp(-3.912\ R/R_v)$$

with range, R, and meteorological visibility range, R_v, in (km), intensity I in (watts), and illuminance E in (watts/cm^2). The source brightness B_s is calculated from the photometric intensity and projected area of the source A_p.

$$B_s\ (\text{candles/m}^2) = I\ (\text{candles})/A_p\ (\text{m}^2).$$

Due to scattering processes in the atmosphere, the apparent brightness of the flash at range R is $B_f = \tau\ B_s$.

This quantity and the equivalent linear dimension of the source are essential inputs to the algorithm for calculating the foveal detection probability given in Ref 1d. The equivalent target diameter is given by $2\sqrt{A_p/\pi}$. The angular subtense of the target (in radians) is just the ratio of the equivalent (target) source diameter to the observation range, R. Much of the literature on foveal detection requires the subtense in minutes of arc. The conversion of the subtense from radians to minutes is:

$$\alpha\ (\text{minutes}) = 3437.7\ \alpha\ (\text{radians}).$$

8. Of course, detection of flash requires that a set of preceeding events occurs in order that foveal detection can occur. The algorithm presented in Ref 1d, treats the process of scanning the sky horizon within a prescribed field of view i. order to obtain an image of a flash on the fovea (or, for the purpose of this MFR, a sensitive central region whose size depends upon background brightness). Also considered there is the probability that a line of sight to the source of flash may not exist due to terrain masking and the probability that detection may fail due to cessation of the flash sequence before detection occurs.

9. Although Ref 1d was written as part of Annex 5 to Ref 1a, it is pre-

DRSAR-SAM

9 JUL 1978

MEMORANDUM FOR RECORD

SUBJECT: Algorithm for Estimating Detection Probabilities and Times for Muzzle Flashes At Night

sented here with the hope of somewhat more general applications. A numerical application of the algorithm is illustrated in Figure 1.

George Schlenker

1 Incl
as

GEORGE J. SCHLENKER
Operations Research Analyst
Methodology Division
Systems Analysis Directorate

Algorithm for Estimating Detection Probabilities and Times for Muzzle Flashes at Night

The instantaneous probability of detection of a firing battery by a single observer, p_{det}, is given by the product of the probabilities for occurrence of the following independent events:

(a) a flash is present and not masked by terrain (p_1)

(b) a sensitive region* of the observer's visual field covers the target image (p_2)

(c) the target image is perceived (p_3)

Then,

$$p_{det} = p_1 p_2 p_3. \tag{5.11}$$

In the following mathematical development, expressions for each of these conditional probabilities will be derived. Since detection of persistently recurring flashes is time-dependent, an expression will be derived for the probability of detection by observers after a period of regular, periodic flashing.

The probability that the observer has intervisibility with the target is strongly dependent upon the type of terrain and the positions of observer and target. It is questionable whether one can apply the results of field simulations using moving vehicles as targets and defensively-situated observers as witnesses to the situation in which firing batteries are the targets and FOs on outposts (OPs) are the witnesses. In the latter case, a

*For background luminance values 10^{-1} foot-lamberts or greater the sensitive region of the visual field is the fovea, the central region of cone vision, with an angular subtense of about 3.5 deg. Blackwell[1] has shown that for background luminance values of the order of 10^{-3} foot-lamberts the entire visual field tested displays nearly the same sensitivity to transient point sources.

Incl 1

more concealed target position will probably be chosen and a less favorable viewing position will generally be available. Thus, the probability of line of sight (LOS) for counterfire observation will likely be less than the probability of LOS for the former situation. In spite of these caveats, one is compelled to use intervisibility results for the former situation because of the absence of trustworthy data pertinent to counterfire intervisibility.

A number of functional relationships have been developed to describe probability of LOS. The one used by TRADOC in the HELLFIRE COEA* is

$$p_{los}(R) = (1 + 2R/R_o)\exp(-2R/R_o) \quad , \qquad (5.12)$$

where

$p_{los}(R)$ = probability of LOS from an observer to one specific target

R = range from observer to target

R_o = average, total LOS segment length in terrain

The terrain statistic R_o is the critical parameter in this expression since $p_{los}(R)$ is quite sensitive to it. Analysis of data from the TETAM field experiment yields a value of R_o of approximately 800 m for the North German Plain and 1500m for site A at the Hunter-Liggett Military Reservation. A group of closely spaced target elements such as vehicles in a platoon can be regarded as a single target for application of this intervisibility model.

To continue with the mathematical development, it is convenient to define additional variables. Notationally,

τ_{bf} = time interval between flashes (constant) (sec)

τ_{dur} = the duration of a single flash (sec)

θ = mean time to detect (sec), given ultimate detection

FOV = search field of view (deg)

---

*P.O-III-1 HELLFIRE Cost and Operational Effectiveness Analysis Addendum, Appendixes N-P, Vol II, (CONF), ACN 21396, TRADOC Combined Arms Combat Dev. Activity, 1 Nov 1975.

α = angular subtense of the target (minutes of arc)

B_f = brightness of the flash (candles/m^2)

B = brightness of the horizon background

C = relative contrast of flash with respect to the horizon background

M = threshold contrast

Then,

$$p_1 = p_{los}\ \tau_{dur}/(\tau_{dur} + \tau_{b_f}) \tag{5.13}$$

$$p_2 = 1 \text{ for FOV<25 deg and } B = 10^{-3} \text{ foot-lamberts}^{[1]} \tag{5.14}$$

$$p_3 = p_3(\alpha,\ B_f,\ B,\ \tau_{dur}) \tag{5.15}$$

An approximate model of p_3 which fits data given by Blackwell and McCready[2] for backgrounds having a brightness of 10^{-3} foot-lamberts or less (3.4 10^{-3} candles/m^2) is given here.

Auxiliary variables σ and Q are defined:

$$\sigma = -0.483\ \tau^{0.158}\ ,\ 0.01<\tau<0.4 \tag{5.16}$$

$$Q = 5.5\ (13\ \alpha\ -4)^{\ \sigma}\ ,0.31<\alpha<52. \tag{5.17}$$

Then,

$$M = 10^Q \tag{5.18}$$

or $\quad Q = \log_{10}M$

and

$$C = B_f/3.4\ 10^{-3} \tag{5.19}$$

[1] Blackwell, H. R. and Moldauer, A. B. Detection Thresholds for Point Sources in the Near Periphery. AD 759739, Engr Res. Inst. Univ. of Mich., Ann Arbor, Mich., June 1958.

[2] Blackwell, H. R. and McCready, D. W., Jr. Foveal Contrast Thresholds for Various Durations of Single Pulses, AD 868307, Engr. Res. Inst. Univ. of Mich., Ann Arbor, Mich., June 1958.

And, the probability of foveal detection

$$p_3 = \Phi(\frac{C-M}{0.39M}) \tag{5.20}$$

with

$$\Phi(z) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{z} e^{-t^2/2} dt. \tag{5.21}$$

Given intervisibility and flash presence, the probability of detection is given by p_{d1} with

$$p_{d1} = p_2 p_3 \tag{5.22}$$

Given LOS, each flash presents a new opportunity to detect, so that the conditional probability distribution of detection time is geometrical with density

$$p_{d1}(1 - p_{d1})^{n-1} \text{ , } n = 1, 2, 3 \ldots$$

Thus,

$$\theta = \Sigma_{n=1}^{\infty} n \tau_{bf} p_{d1} (1 - p_{d1})^{n-1}$$

or

$$\theta = \tau_{bf}/p_{d1} \quad . \tag{5.23}$$

This is the mean time to detect given a detection, i.e., assuming LOS and continuous periodic flashing. If the firing interval is given by τ_{fire}, the probability that the battery is <u>not</u> detected over this interval by a single observer having LOS is, approximately,

$$P\{\text{failure to detect by ith observer}\} = \exp(-\tau_{fire}/\theta). \tag{5.24}$$

Of course, detection may also fail due to a LOS mask. This probability is given above as $1 - P_{los}$.

For m separately-sited observers performing independent visual search, the probability of a detection failure over a firing time interval τ_{fire} is given as follows:

$$P\{\text{detection failure in } \tau_{fire}, \text{ given m observers}\}$$
$$= \Pi_{i=1}^{m} (1 - \pi_i) \qquad (5.25)$$

with

π_i defined for the ith observer:

$$\pi_i = P_{los} (R_i) (1-\exp(-\tau_{fire}/\theta_i)) \ . \qquad (5.26)$$

For a single observer the mean time to detect, given that a detection occurs during the time interval τ_{fire}, $\bar{t}_{dd}$, is obtained as follows. From (5.24), the conditional probability density function for time to detect is

$$f(t) = \theta^{-1}\exp(-t/\theta)/[1 - \exp(-\tau_{fire}/\theta)], \ 0<t<\tau_{fire} \ . \qquad (5.27)$$

Thus,

$$\bar{t}_{dd} = \int_0^{\tau_{fire}} t \ f(t)dt$$

or

$$\bar{t}_{dd}/\theta = \frac{1 - (1 + x) \ e^{-x}}{1 - e^{-x}} \ ,$$

with

$$x = \tau_{fire}/\theta. \qquad (5.28)$$

```
$JOB            GSC,KP=29,RUN=FREE
C***** MAIN PROGRAM TO DRIVE SUBROUTINE DETNIT FOR DETECTION AT NIGHT
      DIMENSION TGTSIZ(6),DURFLS(6),VISRNG(6),TIMFIR(6),RANGE(20)
C***** ASSIGN FIXED PARAMS
      TGTINT=5.0E6
      FOV=25.
      RO=1500.
      TBF=20.
      WRITE (6,108) TGTINT,TBF,FOV,RO
  108 FORMAT(1H0,15HFLASH INTNS (C),15H  TM BTW FS (S),6X,9HFOV (DEG),
     1 9X,6HRO (M)/4F15.4)
C***** READ NUMBER OF ELEMENTS IN EACH ARRAY
      READ (5,100,END=5)  NTGT,NDUR,NTIM,NVISR,NRNG
  100 FORMAT(5(I3,7X))
      READ (5,102) (TGTSIZ(K),K=1,NTGT)
      READ(5,102) (DURFLS(K),K=1,NDUR)
      READ(5,102) (TIMFIR(K),K=1,NTIM)
      READ(5,102) (VISRNG(K),K=1,NVISR)
      READ (5,102) (RANGE(K),K=1,NRNG)
  102 FORMAT(8F10.0)
C***** LOOP THRU TARGET SIZES
      DO 10 KTGT=1,NTGT
      AFB=TGTSIZ(KTGT)
      DIAFB=2.*SQRT(AFB/3.1416)
      SBRITE=TGTINT/AFB
C***** LOOP THRU FLASH DURATIONS
      DO 20 KDUR=1,NDUR
      TDUR=DURFLS(KDUR)
C***** LOOP THRU VISIBILITY RANGES
      DO 30 KVISR=1,NVISR
      RV=VISRNG(KVISR)*1000.
C***** RV IS THE VISIBILITY RANGE IN METERS.  VISRNG IS READ IN KM.
      WRITE (6,110) AFB,TDUR,VISRNG(KVISR)
  110 FORMAT(1H0,15HFLASH AREA (M2),15H DURATION (SEC),
     1 15H VISIB RNG (KM)/3F15.4)
C***** LOOP THRU OBSERVATION RANGES
      DO 40 KRNG=1,NRNG
      R=RANGE(KRNG)*1000.
C***** R IS THE RANGE OF OBSERVATION IN METERS.
      TRANS=EXP(-3.912*R/RV)
      ELUM=TGTINT/685.0E10*TRANS/(RANGE(KRNG))**2
      VISMAG=2.5*ALOG10(3.051E-13/ELUM)
      WRITE (6,111) VISMAG
  111 FORMAT(1H0,9HVIS MAG  ,F10.2)
      WRITE (6,112)
  112 FORMAT(1H0,5X,10HRANGE (KM),15H  TM FIRE (SEC),15H UNC MT DET (S),
     1 9X,5HP(LOS),5X,10HP(FOV DET),9X,6HP(DET),15H CON MT DET (S))
C***** LOOP THRU FIRE-MISSION TIMES
      DO 50 KTIM=1,NTIM
      TFIRE=TIMFIR(KTIM)
      CALL DETNIT(RO,RV,R,DIAFB,TBF,TDUR,TFIRE,SBRITE,FOV,THET,
     1 PLOS,PSCAN,PDFOV,PDET,TDET)
      WRITE (6,114) RANGE(KRNG),TFIRE,THET,PLOS,PDFOV,PDET,TDET
  114 FORMAT(1H ,7F15.4)
   50 CONTINUE
   40 CONTINUE
   30 CONTINUE
   20 CONTINUE
   10 CONTINUE
    5 CALL EXIT
```

```
      END
C**** SUBROUTINE DETNIT -- DETECTION OF MUZZLE FLASH AT NIGHT
**WARNING**  END STATEMENT NOT PRECEDED BY A TRANSFER

      SUBROUTINE DETNIT(RO,RV,R,DIAFB,TBF,TOUR,TFIRE,SBRITE,FOV,THET,
     1 PLOS,PSCAN,PDFOV,PDET,TDET)
C**** THIS PROGRAM CALCULATES THE PROBABILITIES OF OCCURANCE AND
C**** TIMES OF OCCURANCE OF SEVERAL EVENTS GIVEN A SEQUENCE OF
C**** MUZZLE FLASHES AT NIGHT PRESENTED TO A SINGLE OBSERVER.
C**** GLOSSARY OF TERMS:
C**** INPUTS:
C**** RO  AN INPUT RANGE PARAMETER CHARACTERIZING TERRAIN ROUGHNESS (M)
C**** RV  THE METEROLOGICAL VISIBILITY RANGE IN METERS CHARACTERIZING
C**** LIGHT SCATTERING DUE TO ATMOSPHERIC AEROSOLS
C**** R  THE RANGE FROM OBSERVER TO SOURCE OF FLASH (M)
C**** DIAFB  THE EQUIVALENT DIAMETER OF THE VISUAL FIRE BALL (M)
C**** TBF  THE TIME INTERVAL BETWEEN FLASHES (SEC)
C**** TOUR  THE DURATION OF A SINGLE FLASH (SEC)
C**** TFIRE  THE TOTAL FIRING PERIOD FROM COMMENCEMENT OF THE
C**** FIRE MISSION UNTIL END OF MISSION (SEC)
C**** SBRITE  THE INTRINSIC BRIGHTNESS OF THE SOURCE (CANDLES/M2)
C**** FOV  THE OBSERVER'S FIELD OF VIEW (DEG) OVER WHICH SCANNING OCCURS
C**** FOLLOWING ARE PROGRAM OUTPUTS:
C**** THET  THE MEAN TIME TO DETECT A TARGET GIVEN LOS AND UNLIMITED TIME (SEC)
C**** PLOS  THE PROBABILITY THAT A LINE OF SIGHT EXISTS FOR A WELL-SITUATED
C**** GROUND OBSERVER AT RANGE R
C**** PSCAN  THE PROBABILITY THAT AN OBSERVER WILL IMAGE A FLASH ON
C**** A SENSITIVE PORTION OF HIS VISUAL FIELD, GIVEN ITS OCCURANCE
C**** PDFOV  THE PROBABILITY THAT FOVEAL DETECTION WOULD OCCUR GIVEN
C**** THE ABOVE CONDITIONS
C**** PDET  THE PROBABILITY THAT DETECTION OCCURS BEFORE END OF FIRE MISSION
C**** TDET  THE EXPECTED TIME DETECTION OCCURS, GIVEN ITS OCCURANCE (SEC)
C**** COMPUTE PROBABILITY OF LINE OF SIGHT (LOS)
      PLOS=(1.+2.*R/RO)*EXP(-2.*R/RO)
C     P1=PLOS*TOUR/(TOUR+TBF)
C**** P1 IS THE PROB THAT A FLASH IS PRESENT AND LOS EXISTS.
      PSCAN=25./FOV
      IF(PSCAN.GT.1.0) PSCAN=1.0
C**** COMPUTE TRANSMISSIVITY
      TRANS=EXP(-3.912*R/RV)
      BRITE=TRANS*SBRITE
      SUBTNZ=DIAFB/R
      CALL FOVDET(SUBTNZ,TOUR,BRITE,THRESH,PDFOV)
C**** COMPUTE THE UNCONSTRAINED MEAN TIME TO DETECT
      PD1=PSCAN*PDFOV
      IF(PD1.LE.0.0) PD1=1.E-20
      THET=TBF/PD1
      X=TFIRE/THET
      EXPMX=EXP(-X)
      PDET=PLOS*(1.-EXPMX)
      TDET=(1.-(1.+X)*EXPMX)/(1.-EXPMX)*THET
      RETURN
      END
C**** FOVEAL DETECTION SUBROUTINE **** FOVEAL DETECTION SUBROUTINE

      SUBROUTINE FOVDET(TGTSIZ,EXPOSE,BRITE,THRESH,PDET)
C**** SUBROUTINE FOVDET(TGTSIZ,EXPOSE,BRITE,THRESH,PDET)
C**** THIS PROGRAM CALCULATES THE PROBABILITY OF FOVEAL DETECTION OF A
C**** TARGET OF PRESCRIBED SIZE, EXPOSURE DURATION AND LUMINOSITY
C**** AGAINST THE NIGHT SKY HORIZON, GIVEN FOVEAL EXPOSURE.
```

```
C**** TGTSIZ IS THE ANGULAR SUBTENSE OF THE TARGET IN RADIANS
C**** EXPOSE IS THE TARGET EXPOSURE IN SECONDS.  THE APPROXIMATION
C**** GIVEN HERE IS VALID FOR EXPOSURES BETWEEN 10 AND 400 MILLISECONDS.
C**** BRITE IS THE BRIGHTNESS OF THE TARGET IN CANDLES/M2.
C**** THRESH IS THE CONTRAST THRESHOLD FOR FOVEAL DETECTION WHERE
C**** THE CONTRAST IS DEFINED AS THE BRIGHTNESS ADDED BY THE TARGET
C**** DIVIDED BY THE BRIGHTNESS OF THE BACKGROUND.
C**** PDET IS THE PROBABILITY OF DETECTING THE TARGET GIVEN
C**** THAT IT IS IMAGED ON THE FOVEA WITH A BACKGROUND LUMINANCE
C**** OF 3.4E-3 CANDLES/M2 OR LESS.
C**** SNORM(Z) IS THE STANDARD NORMAL PROBABILITY INTEGRAL.
C****
C**** CONVERT THE TARGET SIZE TO MINUTES OF ARC.
      ALPHA=3437.7*TGTSIZ
      IF(EXPOSE.LT.0.01) GO TO 3
      IF(EXPOSE.GT.0.40) GO TO 3
      IF(ALPHA.GT.100.) GO TO 4
      IF(ALPHA.LT.0.31) GO TO 5
      SIGMA=-0.483*EXPOSE**0.158
      Q=5.5*(13.0*ALPHA-4.0)**SIGMA
      THRESH=10.**Q
      CNTRST=BRITE/0.003426
      ARG=(CNTRST-THRESH)/(0.39*THRESH)
      PDET=SNORM(ARG)
      RETURN
    3 CONTINUE
C**** INPUT ERROR
      WRITE (6,10)
   10 FORMAT(1H0,36HTARGET EXPOSURE IS NOT WITHIN LIMITS)
      CALL EXIT
C**** ANGULAR SUBTENSE IS TOO GREAT.
    4 CONTINUE
      WRITE (6,11)
   11 FORMAT(1H0,19HTARGET IS TOO CLOSE)
      CALL EXIT
    5 CONTINUE
C**** TARGET IS TOO SMALL FOR THE EYE TO RESOLVE.
      THRESH=0.0
      PDET=0.0
      RETURN
      END

$ENTRY

FLASH INTNS (C)  TM BT= FS (S)     FOV (DEG)        RO (M)
  5000000.0000      20.0000         25.0000       1500.0000

FLASH AREA (M2) DURATION (SEC) VISIB RNG (KM)
     60.0000        0.0600          5.0000

VIS MAG        1.68

    RANGE (KM)  TM FIRE (SEC) UNC MT DET (S)        P(LOS)      P(FOV DET)          P(DET) CON MT DET (S)
     14.0000       300.0000         20.0000          0.0000         1.0000           0.0000        19.9999
     14.0000       600.0000         20.0000          0.0000         1.0000           0.0000        20.0000

VIS MAG        1.88

    RANGE (KM)  TM FIRE (SEC) UNC MT DET (S)        P(LOS)      P(FOV DET)          P(DET) CON MT DET (S)
     14.2000       300.0000         20.0000          0.0000         1.0000           0.0000        19.9999
```

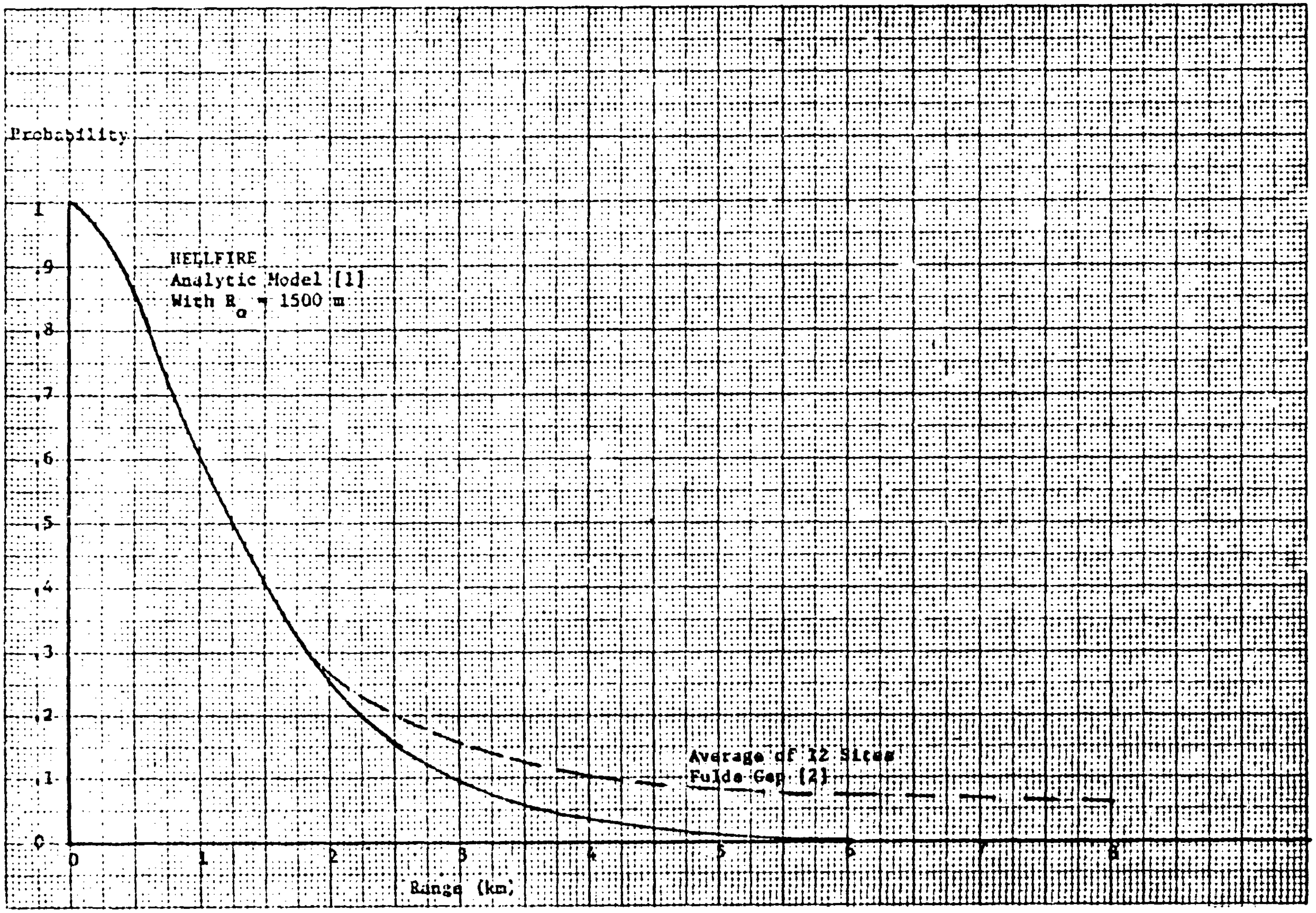

Figure 1a. Probability of LCS From Ground Observer to Random Target at Range R

Notes for Figure 1a.

[1] P.O-III-1 HELLFIRE Cost and Operational Effectiveness Addendum, Appendixes, N - P, Vol. II(u)(CONF) ACN 21396, TRADOC Combined Arms Dev. Activity, Nov. 1975.

[2] P. 36, Boehne, R. C. and Gallagher, V. M. Environmental Models For the Design and Evaluation of Systems Whose Performance is Line-of-Sight Limited, AD 834455, Stanford Research Institute, August 1967.

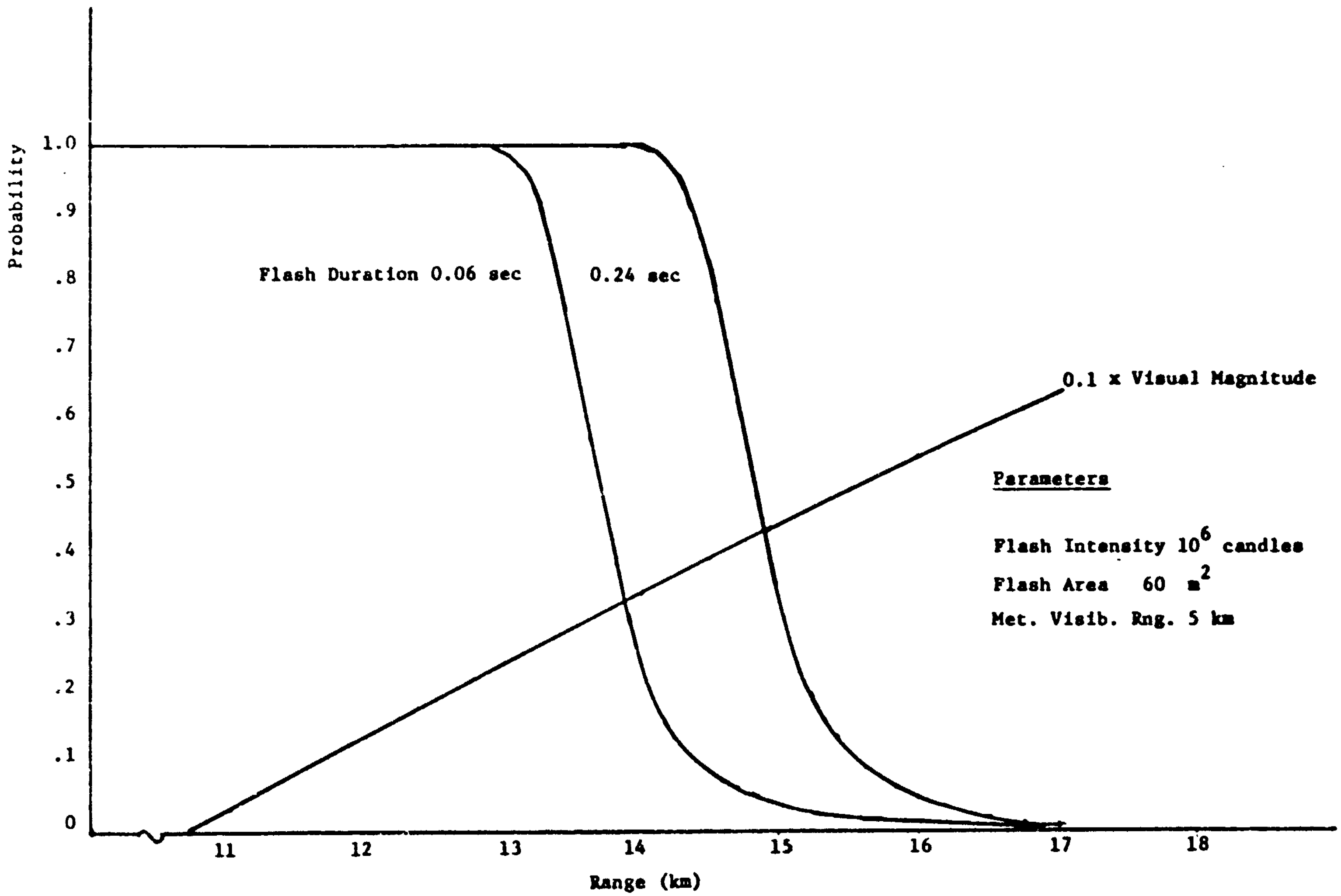

Figure 1b. Probability of Foveal Detection Vs Range for Selected Parameters

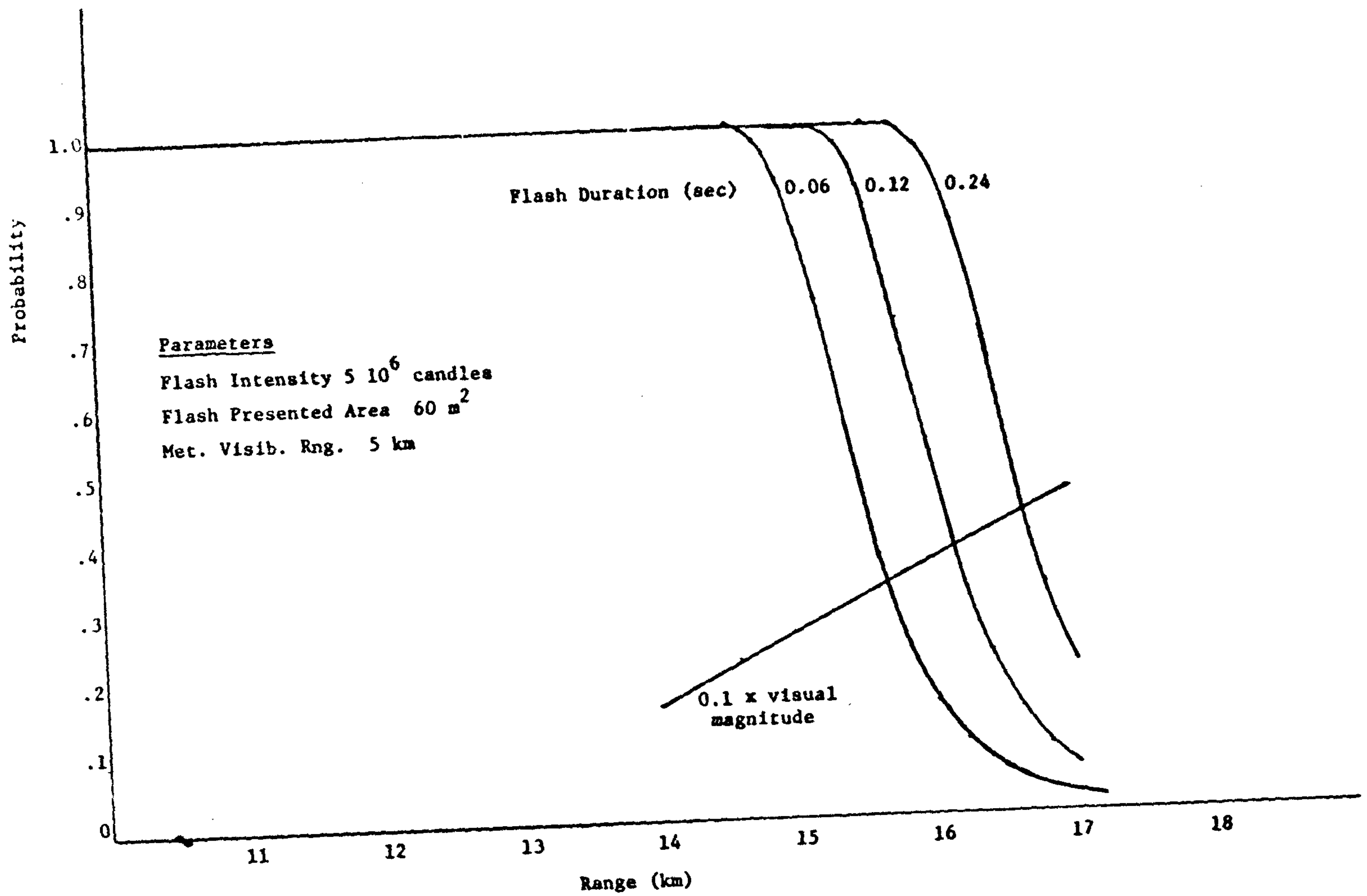

Figure 1c. Probability of Foveal Detection Vs Range for Selected Parameters

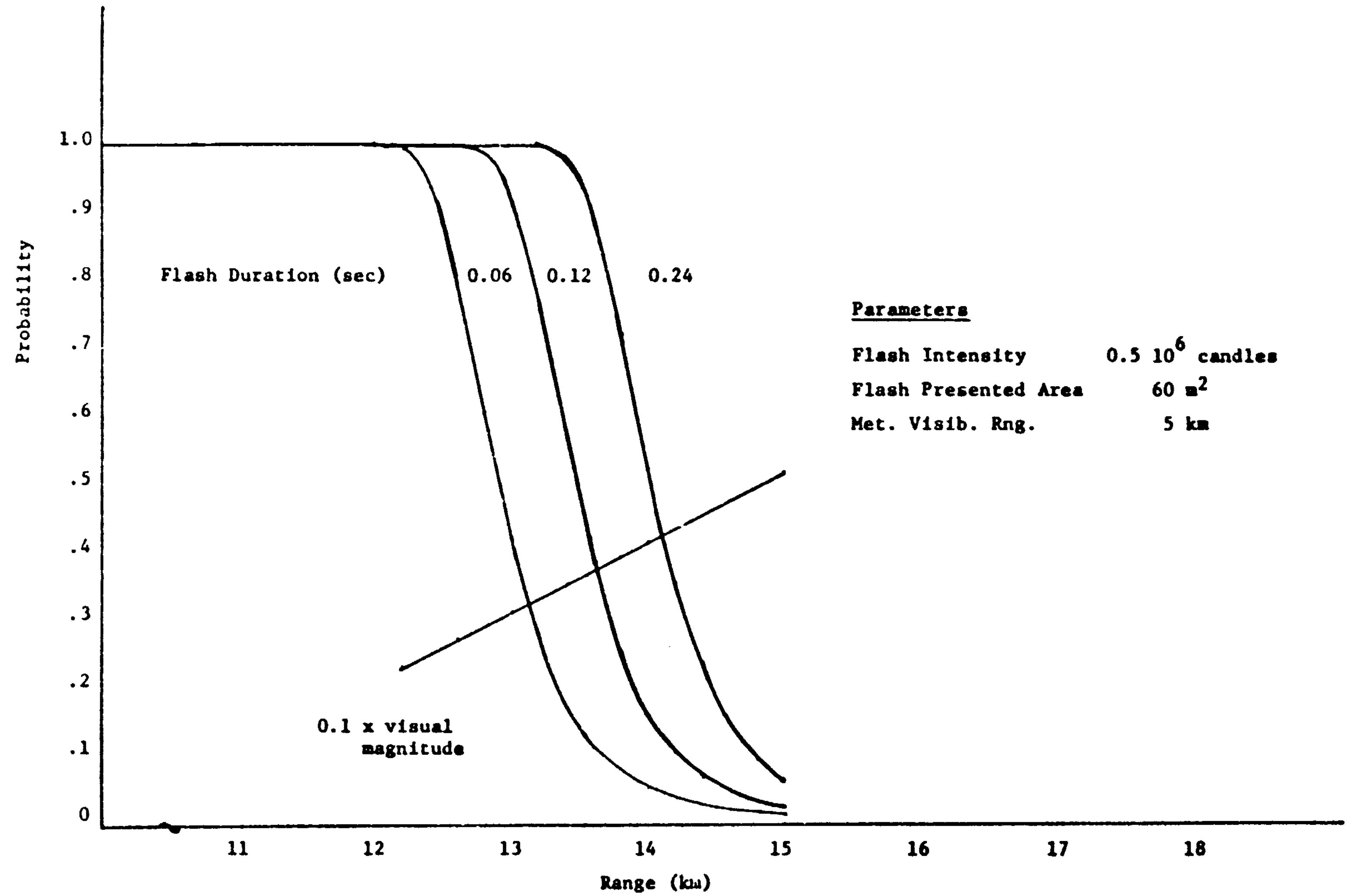

Figure 1d. Probability of Foveal Detection Vs Range for Selected Parameters

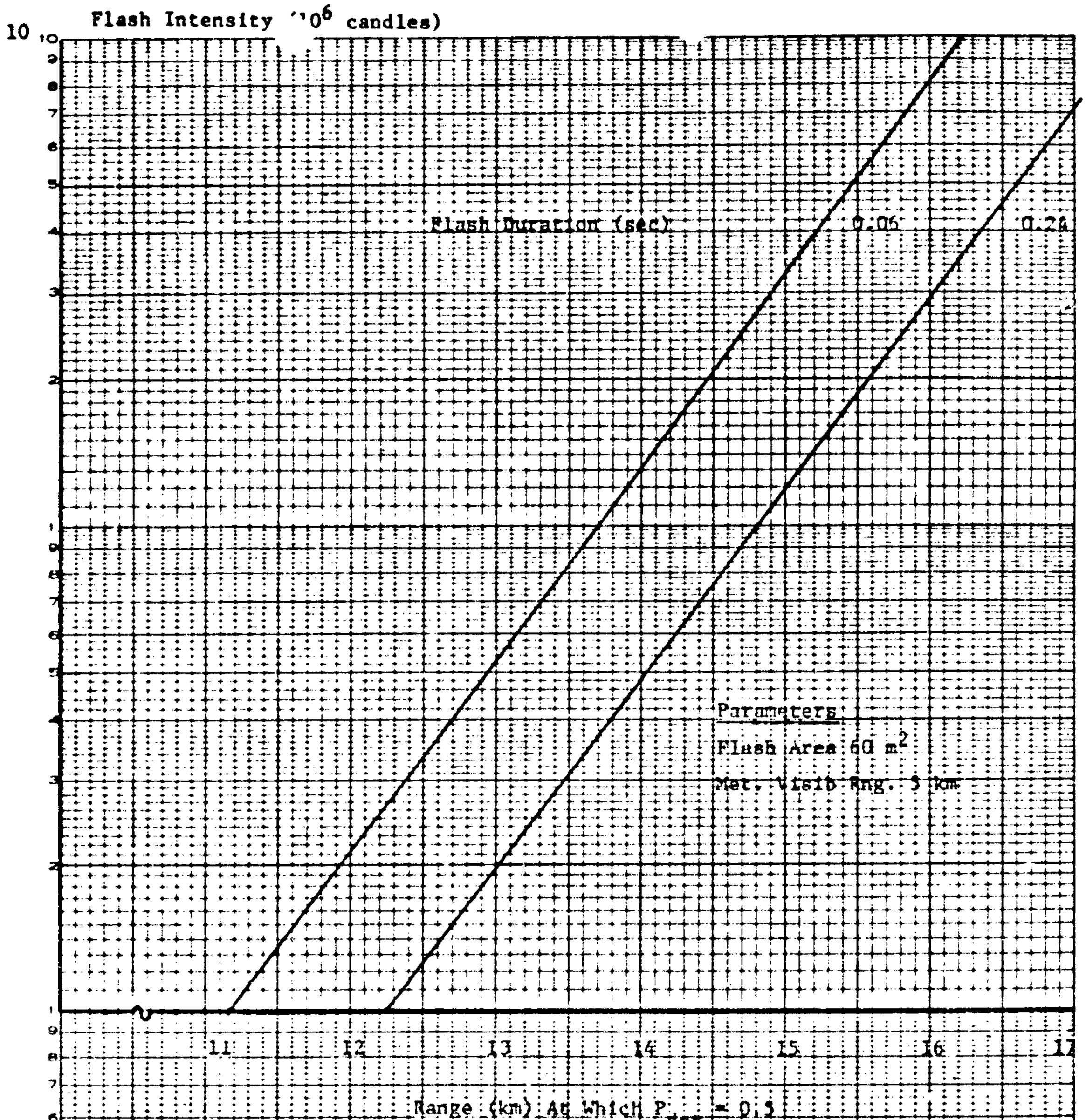

Figure 6e. Flash Intensity Required for Detection at Range R

DRAFT LETTER OF AGREEMENT (LOA) FOR THE DEVELOPMENT

OF A 155MM ILLUMINATING PROJECTILE

Next page is blank.

DRSAR-SAM (19 Jul 76)
SUBJECT: Draft Letter of Agreement (LOA) for the Development of a 155mm Illuminating Projectile

TO DRSAR-RDP   FROM DRSAR-SA   DATE 4 AUG 1976 CMT 2
Mr. Haase/cl/3177

1. References:

a. DF, AMSAR-RDP, 2 Apr 76, Proposed Letter of Agreement (LOA) for the Development of a 155mm Illuminating Projectile.

b. CMT 2 on a., above, DRSAR-SAM, 9 Apr 76, subject as above.

2. DRSAR-SAM has reviewed the subject LOA as requested. Our comments are provided as Incl 3.

3. This LOA is a rewrite of a previous proposed LOA (Ref 1a) which we also reviewed. Our previous comments were provided via Ref 1b. Those comments addressed a broad spectrum of subject matter, ranging from editorial changes to fundamental issues involving systems effectiveness and safety aspects. However, except for the editorial changes, the subject LOA does not reflect our comments at all.

4. With respect to both effectiveness and safety, the LOA proposes a new round which will be "more effective" and "safer" than the M485A2. If, in fact, the "measures of effectiveness" are not defined, then we question whether it is possible to identify those baseline performance characteristics of the M485A2 which will be exceeded by the new round. Likewise, we question how can it be determined that the user requires a new illuminating round unless it can be shown that the M485A2 fails to meet certain well-defined safety and operational effectiveness criteria. DRSAR-SA contends that these are fundamental issues which require resolution prior to initiation of an expensive development program.

M. Rhian
M. RHIAN
Acting Director
Systems Analysis Directorate

1 Incl
wd incl 1&2
Added 1 incl
3. DA 2028

DISPOSITION FORM

For use of this form, see AR 340-15, the proponent agency is TAGCEN.

S-29 July 76

REFERENCE OR OFFICE SYMBOL: DRSAR-RDP

SUBJECT: Draft Letter of Agreement (LOA) for the Development of a 155mm Illuminating Projectile

TO SEE DISTRIBUTION

FROM DRSAR-RDP

DATE 1 4 JUL 1976

CMT 1

Mr. Denney/dw/4564

1. References:

a. Letter, ATCD-CF, HQ, TRADOC, 18 June 1976, SAB (Incl 1).

b. Letter, DRSAR-RDP, HQ, ARMCOM, June 1976, SAB (Incl 2).

2. Request draft LOA (Inclosure 1 to reference 1a) and comments contained in 1st indorsement to reference 1b above be reviewed and comments or concurrence be provided to HQ, ARMCOM, ATTN: DRSAR-RDP, NLT 29 July 1976.

Richard L. Janney

RICHARD L. JANNEY
Acting Chief, Tech Programs Div

2 Incl
as

DISTRIBUTION:

DRSAR-AS
DRSAR-CPE
DRSAR-MAE
DRSAR-MM
DRSAR-PPV
DRSAR-PTT
DRSAR-QAR
DRSAR-RDG
DRSAR-RDF
DRSAR-RDI
DRSAR-SA

DA FORM 1 FEB 62 2496 REPLACES DD FORM 96, WHICH IS OBSOLETE. GPO-1975-665-422/1063

RECOMMENDED CHANGES TO PUBLICATIONS AND BLANK FORMS For use of this form, see AR 310-1; the proponent agency is the US Army Adjutant General Center.	Use Part II (reverse) for Repair Parts and Special Tool Lists (RPSTL) and Supply Catalogs/Supply Manuals (SC/SM).	DATE 31 Jul 76
TO: (Forward to proponent of publication or form) (Include ZIP Code) DRSAR-RDP	FROM: (Activity and location) (Include ZIP Code) DRSAR-SAM	

PART I - ALL PUBLICATIONS (EXCEPT RPSTL AND SC/SM) AND BLANK FORMS

PUBLICATION/FORM NUMBER	DATE	TITLE
ATSF-CD-WC/SARPA-AD-D-R4	18 Jun 76	Proposed Letter of Agreement (LOA) for the Development of a 155mm Illuminating Projectile.

ITEM NO.	PAGE NO.	PARA-GRAPH	LINE NO.*	FIGURE NO.	TABLE NO.	RECOMMENDED CHANGES AND REASON (Exact wording of recommended change must be given)
1	1 6	1.a. 1.a.	.and of ANNEX A			CHANGE: The LOA concludes that the maneuver force cannot be supported with illumination in the upper 42% of XM198 range capabilities. But, a logical argument to support the need for illumination at 24km range is missing. State the actual requirement REASON: The AD program is predicated on a need for illumination at extended ranges. An argument for that need should be developed.
2	6	1.a.	3			CHANGE: State what levels the effective illumination has been reduced from, or to. Otherwise, show how the "reduction of 50%" was quantified. REASON: Technical data to substantiate the need for the system.
3	1	2.b.	3			CHANGE: Define "effective illumination" in quantitative terms. REASON: Clarity.
4	1 2	2.c. 3.b.	and 5&6			CHANGE: The requirement is stated relative to the M485A2. The "metal parts fallout" of the M485A2 should be quantified in the text to provide a baseline from which the 25% reduction can be measured. REASON: The requirement, as stated, is too vague.
5	1	3a	4			CHANGE: Include a numerical value for the illumination "currently provided by the M485A2." REASON: Since the requirement is stated relative to the M485A2, a baseline value for the M485A2 should be stated. As it is, the requirement is too vague.
6	1	3.a.				REMARKS: The acknowledgements that "...overall battlefield effectiveness cannot be accurately quantified..." and "...factors to quantify combat

*Reference to line numbers within the paragraph or subparagraph.

TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE AUTOVON, PLUS EXTENSION	SIGNATURE
MORRIS C. JOHNSON, Chief Methodology Division	793-5075/5930	Morris C. Johnson

DA FORM 2028 Incl 3 REPLACES DA FORM 2028, 1 DEC 68, WHICH WILL BE USED.

RECOMMENDED CHANGES TO PUBLICATIONS AND BLANK FORMS

For use of this form, see AR 310-1; the proponent agency is the US Army Adjutant General Center.

Use Part II (reverse) for Repair Parts and Special Tool Lists (RPSTL) and Supply Catalogs/Supply Manuals (SC/SM).

DATE: 30 Jul 76

TO: (Forward to proponent of publication or form) (Include ZIP Code)
DRSAR-RDP

FROM: (Activity and location) (Include ZIP Code)
DRSAR-SAM

PART I - ALL PUBLICATIONS (EXCEPT RPSTL AND SC SM) AND BLANK FORMS

PUBLICATION/FORM NUMBER: ATSF-CD-WC/SARPA-AD-D-R4

DATE: 18 Jun 76

TITLE: Proposed Letter of Agreement (LOA) for the Development of a 155mm Illuminating Projectile

ITEM NO	PAGE NO	PARA-GRAPH	LINE NO.*	FIGURE NO.	TABLE NO.	RECOMMENDED CHANGES AND REASON (Exact wording of recommended change must be given)
						effectiveness remain elusive..." should stimulate considerable concern within TRADOC and DARCOM. The combat effectiveness of all conventional weapons systems under nighttime conditions depends upon the ability to acquire targets, to effectively engage them, and to assess damage inflicted upon them. Illumination enhances that nighttime capability.
7	2	3.b.	4			REMARK: Based on the remarks made in Para 2.c.(1), it is not readily apparent how that "judgment" can be made at this point in time. If, in fact, the "measures of effectiveness" are not defined and if the sensitivity of "effectiveness" to the critical factors is elusive, then how can we judge that the battlefield effectiveness will be 3 to 7 times better than the M485A2?
8	2	3.a.	all			REMARK: Perhaps the "measure of effectiveness" for illuminating rounds needs to be examined and defined prior to initiation of a development program leading to a new "end item." It seems that the sensitivity of "effectiveness" to each of the factors identified in Para 3.a. should be established so that needed improvements can be stated in more specific terms.
9	3	6.a.				CHANGE: The paragraph 6.a. should be separated into two paragraphs 6.a. (Operational Effectiveness) and 6.b. (Required Performance Characteristics). Change the current 6.b. to 6.c., and the current 6.c. to 6.d. REASON: Clearly, the most critical issue (or unknown) is the operational effectiveness of illuminating rounds. Quantitative estimates of the tactical advantages to be gained through the use of illumination must be developed from considerations of use concepts, tactics and doctrine.

*Reference to line numbers within the paragraph or subparagraph.

TYPED NAME, GRADE OR TITLE | TELEPHONE EXCHANGE AUTOVON, PLUS EXTENSION | SIGNATURE

DA FORM 2028 REPLACES DA FORM 2028, 1 DEC 68, WHICH WILL BE USED.

RECOMMENDED CHANGES TO PUBLICATIONS AND BLANK FORMS For use of this form, see AR 310-1; the proponent agency is the US Army Adjutant General Center.	Use Part II (reverse) for Repair Parts and Special Tool Lists (RPSTL) and Supply Catalogs/Supply Manuals (SC/SM).	DATE 30 Jul 76
TO: (Forward to proponent of publication or form) (Include ZIP Code) DRSAR-RDP	FROM: (Activity and location) (Include ZIP Code) DRSAR-SAM	

PART I - ALL PUBLICATIONS (EXCEPT RPSTL AND SC SM) AND BLANK FORMS

PUBLICATION/FORM NUMBER	DATE	TITLE
ATSF-CD-WC/SARPA-AD-D-R4	18 Jun 76	Proposed Letter of Agreement (LOA) for the Development of a 155mm Illuminating Projectile

ITEM NO.	PAGE NO.	PARA-GRAPH	LINE NO.*	FIGURE NO.	TABLE NO.	RECOMMENDED CHANGES AND REASON (Exact wording of recommended change must be given)
						Then, the sensitivity of the operational effectiveness to changes in systems performance characteristics can be quantified in meaningful terms.
10	3	6.a.				REMARK: The concept of "useful range of employment" should also be studied. The assumption that maximum ranges of illuminating projectiles must be equal to maximum ranges of other projectiles should be examined in detail.
11	4 4&5	8. 10.				REMARK: Significant effort is likely to be required in the definition of quantitative "measures of effectiveness," "math model building," and the conduct of "sensitivity analyses" early in the development cycle. If this work is not done prior to or early in the cycle, then quantitative evaluation of trade-off options and evaluation of the projectile's performance at DT/OT I testing may not be possible. Therefore, it is suggested that the milestone schedule and funding statement reflect adequate resources for the development of analytic methods and quantitative estimates for operational effectiveness.

*Reference to line numbers within the paragraph or subparagraph.

TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE AUTOVON, PLUS EXTENSION	SIGNATURE

DA FORM 1 FEB 74 2028 REPLACES DA FORM 2028, 1 DEC 68, WHICH WILL BE USED.

Next page is blank.

STANDARDS FOR TESTING LASER DESIGNATORS

Next page is blank.

DRSAR-SA (26 Jul 76) 1st Ind
SUBJECT: Standards for Testing Laser Designators

HQ, US Army Armament Command, Rock Island, IL 61201 1 ? AUG 1976

TO: Commander, US Army Test and Evaluation Command, ATTN: DRSTE-ME,
Aberdeen Proving Ground, MD 21005

1. Reference is made to Technical Report No. 111700-1-F, Environmental Research Institute of Michigan, August 1975, title: Evaluation of Target Reflectance Illumination Model With Second-Order (TRIMS).

2. As requested in the basic letter, the draft document, subject as above, has been reviewed. Comments and recommended changes are provided as Inclosure 1.

3. Our comments refer repeatedly to the ERIM Target Reflectivity Model whose validation is described in reference 1. This model has proved useful to ARMCOM in examining the laser-target-projectile interface. It is suggested that appropriate application of the model to new designation situations may significantly reduce the requirement for live firings. The Physics Team in the Rodman Labs is the custodian for this model. Point of contact is Dr. Mike Amoruso, AUTOVON 793-4683.

FOR THE COMMANDER:

1 Incl
as

M. RHIAN
Acting Director
Systems Analysis Directorate

CF:
DRCPM-CAWS-FO (COL R. Nulk) w/o incl

Drsar SA

DEPARTMENT OF THE ARMY Mr. Wise/lt/283-2478
HEADQUARTERS, U. S. ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MARYLAND 21005

S - 20 Sep 76

DRSTE-ME 26 JUL 1976

SUBJECT: Standards for Testing Laser Designators

SEE DISTRIBUTION

1. Reference is made to meeting at WSMR, 9-10 June 1976, subject: Uniform Standards for Laser Designator Developments.

2. TECOM was directed by DARCOM to:

a. Develop standards to assure uniformity in measurement of those laser designator technical parameters that bear on conditional hit probability.

b. Develop policy concerning control of the data collection for laser designators as required for the single integrated development testing cycle (SIDTC).

c. Determine cost savings that can be accrued by minimizing live firings.

3. The inclosed draft report documents the results of TECOM's efforts in each of the above areas of concern.

4. [illegible] procedures, which are shown within the report, are all new [illegible] were developed specifically for this effort. They must be thoroughly validated before being utilized as testing standards.

5. As agreed at the referenced meeting, a copy of the draft report is provided for your comments. Of major importance are your views concerning:

a. The technical adequacy of the test procedures.

b. Recommended changes to the test procedures.

c. Required follow-on action.

Comments should be forwarded to HQ, TECOM, ATTN: DRSTE-ME. They should arrive by COB 20 September 1976.

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

EXPIRES 26 July 1977

26 JUL 1976

DRSTE-ME
SUBJECT: Standards for Testing Laser Designators

6. The points of contact at TECOM are Mr. Sidney Wise and Dr. Norman Pentz, Autovon 283-2170/3677/2478.

FOR THE COMMANDER:

Sidney Wise
SIDNEY WISE
Director, Methodology Improvement

DISTRIBUTION LIST

	No. of Copies
Commander Advanced Attack Helicopter ATTN: DRCPM-AAH-OR (J. Romano) DRCPM-AAH-TM (T. Mueller) PO Box 209 St Louis, MO 63166	2
Commander Advanced Scout Helicopter ATTN: DRCPM-ASH-T (D. Checkwick) US Army Aviation Systems Command St Louis, MO 63166	1
Commander US Army Missile Command ATTN: DRCPM-HFE (V. Stallcup; Roger Comer) (1) DRSMI-RGT (C. Lewis; J. Leonard) (2) DRSMI-RE (Dr. G. Emmons) (1) DRSMI-RTP (Mr. W. B. Wahlheim; Mr. Crocker) (1) Redstone Arsenal, AL 35809	5
Commander Precision Laser Designator ATTN: DRCPM-LDT (R. Keenum) DRCPM-LDE (G. Starkey) Redstone Arsenal, AL 35809	2
Commander US Army Armament Command ATTN: DRCPM-CAWS-FO (H. Clinkenbeard) Redstone Arsenal, AL 35809	1
Commander US Army Yuma Proving Ground ATTN: STEYP-MAA (J. Sanborn) STEYP-MDP (L. Weeks) STEYP-COA (R. Miller) Yuma, AZ 85364	3
Commander US Army Training and Doctrine Command ATTN: ATCD-T (R. Radda) ATCD-CM (LTC R. W. Quigley) ATCD-CF (CPT D. Gunn) ATCD-SC (Mr. A. H. McDonald) Ft Monroe, VA 23651	4

	No. of Copies
Commander US Army Electronics R&D Command ATTN: DRSEL-CT-L-A (J. Schwartz) Ft Monmouth, NJ 07703	2
Commander US Army Armament Command ATTN: DRSAR-SA (G. Schlenker) Rock Island, IL 61201	1
Commander US Army Development & Readiness Command ATTN: DRCDE-RR (Mr. McGregor; CPT Bosscha) 5001 Eisenhower Ave. Alexandria, VA 22333	2
Commander US Army Harry Diamond Lab ATTN: DRXDO-DBD (Mr. Melvin Sword; Mr. T. Gleason) 2800 Powder Mill Rd Adelphi, MD 20783	2
Commander Marine Corps Development and Education Center ATTN: Chief, Fire Power Division (CWO Fleming) Quantico, VA 22134	1
Commander US Army Operational Test & Evaluation Agency ATTN: CSTE-STO-C (Larry Leiby) 5600 Columbia Pike Falls Church, VA 22041	1
Commander US Army Development & Readiness Command ATTN: DRCDE-DE (H. Blodgett) 5001 Eisenhower Ave. Alexandria, VA 22333	1
Commander US Army White Sands Missile Range ATTN: STEWS-TE-AG (Mr. Shaw; Mr. Jones) STEWS-TE-MD (Mr. J. Dage) STEWS-TE (COL Madden) WSMR, NM 88002	3

	No. of Copies
Commander US Army Electronic Proving Ground ATTN: STEEP-MT-I (J. B. Wilburn) STEEP-MT (COL Phillips) Ft Huachuca, AZ 85613	2
Commander US Army Aberdeen Proving Ground ATTN: STEAP-MT-I (A. Lopolito) STEAP-MT (B. Sissom) APG, MD 21005	2
HQ AFSC/XRLW ATTN: LTC Wm. S. Seufert Andrews Air Force Base, MD 20334	2
Commander Naval Surface Weapon Center ATTN: Code DF-32 (Mr. Foutenant) Dahlgren, VA 22448	1
Commander Navy Air Systems Command ATTN: AIR-03P23 (Dr. A. Habayeb) Washington, DC 20361	1
Director US Army Materiel Systems Analysis Activity ATTN: DRXSY-GS (D. Barnhardt) DRXSY-GS (D. Frederick) DRXSY-RM (H. Harris) APG, MD 21005	3
Director US Army Human Engineering Lab ATTN: DRXHE-SP (Mr. Cheever) APG, MD 21005	1
Director US Army Ballistic Research Laboratories ATTN: DRXBR-BM (Mr. H. Reed) APG, MD 21005	1
Joint Services Electro-Optical Countermeasures Test Programs ATTN: DRSEL-WL-TD (LTC E. N. Laughlin) WSMR, NM 88002	1
PM, Cannon Artillery Weapons Systems US Army Armament Command ATTN: DRCPM-CAWS-PA (D. Riel) Rock Island, IL 61201	1

RECOMMENDED CHANGES TO PUBLICATIONS AND BLANK FORMS For use of this form, see AR 310-1; the proponent agency is the US Army Adjutant General Center.	Use Part II (reverse) for Repair Parts and Special Tool Lists (RPSTL) and Supply Catalogs/Supply Manuals (SC/SM).	DATE 11 AUG 76

TO: (Forward to proponent of publication or form) (Include ZIP Code)	FROM: (Activity and location) (Include ZIP Code)
Commander US Army Test & Evaluation Command ATTN: DRSTE-ME Aberdeen Proving Ground, MD 21005	Commander US Army Armament Command ATTN: DRSAR-SA Rock Island, IL 61201

PART I - ALL PUBLICATIONS (EXCEPT RPSTL AND SC/SM) AND BLANK FORMS

PUBLICATION/FORM NUMBER	DATE	TITLE
Draft Report	July 1976	Standards for Testing Laser Designators

ITEM NO.	PAGE NO.	PARA-GRAPH	LINE NO.*	FIGURE NO.	TABLE NO.	RECOMMENDED CHANGES AND REASON (Exact wording of recommended change must be given)
1	4	3b(4)	2			COMMENT: Add "as seen by the seeker" to the sentence: "(Energy distribution in plane of target)." REASON: Clarity. It is noted that the distinction between seeker frame of reference and designator frame is frequently obscured by use of the term "plane of target."
2	4	1	6			COMMENT: In referring to the "conditional" hit probability some definition is required. In an operational setting the probability of hitting the target with (CLGP) Copperhead depends somewhat upon target location error (TLE). The TLE in turn may depend upon rangefinder performance. However, if the conditions involve acquisition and lockon, guidance accuracy <u>does not</u> depend strongly upon the TLE or, alternatively, the position of the target within the footprint.
3	5	6b	2			COMMENT: Suggest deleting "MICOM" and replacing with organizations performing flight simulations. REASON: A tri-service measurement spec requires greater generality.
4	7	10	3			COMMENT: Add "as seen by the designator" to "(in the target plane)." REASON: Atmospheric jitter is usually defined in a plane normal to the beam.
5	12	7	2			COMMENT: Replace "95%" with "90%". REASON: Consistency. 90% is usually the boundary selected for defining the laser beam. See definition of beam divergence and maximum range elsewhere in the report, e.g., p. 13.
6	15	6b	2			COMMENT: Delete "by MICOM." REASON: Same as item 3.

*Reference to line numbers within the paragraph or subparagraph.

TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE/AUTOVON, PLUS EXTENSION	SIGNATURE
GEORGE J. SCHLENKER DRSAR-SAM Incl 1	ATV 793-5075	[illegible]

DA FORM 2028 REPLACES DA FORM 2028, 1 DEC 68, WHICH WILL BE USED.

RECOMMENDED CHANGES TO PUBLICATIONS AND BLANK FORMS For use of this form, see AR 310-1; the proponent agency is the US Army Adjutant General Center.	Use Part II (reverse) for Repair Parts and Special Tool Lists (RPSTL) and Supply Catalogs/Supply Manuals (SC/SM).	DATE 11 AUG 197[illegible]
TO: (Forward to proponent of publication or form) (Include ZIP Code) Commander US Army Test & Evaluation Command ATTN: DRSTE-ME Aberdeen Proving Ground, MD 21005	FROM: (Activity and location) (Include ZIP Code) Commander US Army Armament Command ATTN: DRSAR-SA Rock Island, IL 61201	

PART I - ALL PUBLICATIONS (EXCEPT RPSTL AND SC/SM) AND BLANK FORMS

PUBLICATION/FORM NUMBER	DATE	TITLE
Draft Report	July 1976	Standards for Testing Laser Designators

ITEM NO.	PAGE NO.	PARAGRAPH	LINE NO.*	FIGURE NO.	TABLE NO.	RECOMMENDED CHANGES AND REASON (Exact wording of recommended changes must be given)
7	16	3a(2)	4			COMMENT: Indicate and clarify frame of reference. REASON: Actually, as noted on p. 58, the distribution of pulse-to-pulse energy as seen by a target being tracked by a designator also depends upon the geometry of the target, target reflectance characteristics, and laser beam jitter. These characteristics are considered in signature analyses performed using the ERIM Laser Target Reflectivity Model.
8	23	6.5.2.2	5			COMMENT: Change "6.5.2.1 above" to "6.5.1.1 above." REASON: Error in reference.
9	59	3 and following				COMMENT: The instrumentation preparation, procedure, and analysis require additional detail to be useful. Further, a live firing seems unnecessary here. REASON: From the description of the test given on pp 59 and 60, it appears that the only purposes served by the live firing are (a) to define a trajectory or set of reference directions for the seeker during terminal homing and (b) to provide a single sample of guidance accuracy to correlate with an analytic prediction for that sample of designator-referenced signature. For a validated target reflectivity model such as the ERIM Model (Ref 1) it is only necessary to describe the beam position and energy relative to the designator to predict the energy incident upon a receiver placed in any arbitrary position. It is, of course, unnecessary to actually fire a projectile to adequately determine a reference trajectory. Such a trajectory can be simulated with adequate precision to define the set of seeker reference directions to be used in the target reflectivity model. Thus, a non-firing tracking and designation test provides sufficient information to analytically predict the signature

DA [illegible] 2028

RECOMMENDED CHANGES TO PUBLICATIONS AND BLANK FORMS

For use of this form, see AR 310-1, the proponent agency is the US Army Adjutant General Center.

Use Part II (reverse) for Repair Parts and Special Tool Lists (RPSTL) and Supply Catalogs/Supply Manuals (SC/SM).

DATE: 11 AUG 1976

TO: (Forward to proponent of publication or form) (Include ZIP Code)

Commander
US Army Test & Evaluation Command
ATTN: DRSTE-ME
Aberdeen Proving Ground, MD 21005

FROM: (Activity and location) (Include ZIP Code)

Commander
US Army Armament Command
ATTN: DRSAR-SA
Rock Island, IL 61201

PART I - ALL PUBLICATIONS (EXCEPT RPSTL AND SC/SM) AND BLANK FORMS

PUBLICATION FORM NUMBER	DATE	TITLE
Draft Report	July 1976	Standards for Testing Laser Designators

ITEM NO.	PAGE NO.	PARA-GRAPH	LINE NO.*	FIGURE NO.	TABLE NO.	RECOMMENDED CHANGES AND REASON (Exact wording of recommended change must be given)
						seen by the seeker in terms of both irradiance at the dome and apparent motion of the energy centroid from pulse to pulse. A set of tracking runs provides the basis for constructing a stochastic model of the spot motion noise. It is felt that such a model used in connection with a valid flight simulation is a more useful and trustworthy estimator of both guidance accuracy and signature referenced to the seeker than is a single live firing.
10	71	2a	3			COMMENT: Add to end of sentence: "and to compare results from different designators." REASON: The primary justification for having standard targets, for systems capable of attacking many different types of targets, is to facilitate comparisons.
11	81				3	COMMENT: Change: "Total No. of Man-Hours" to "Man-Weeks." REASON: Typographical error. In general, the cost analysis performed here appears conservative in terms of cost avoided.

*Reference to line numbers within the paragraph or subparagraph

TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE/AUTOVON, PLUS EXTENSION	SIGNATURE
	793 5930 5875	[illegible]

DA FORM 2028 REPLACES DA FORM 2028, 1 DEC 68, WHICH WILL BE USED. Next page is blank.

DRAFT TEST DESIGN PLANE (TDP) FOR DTII OF THE

BIOLOGICAL DETECTOR AND WARNING SYSTEM, XM19/XM2

Next page is blank.

DRSAR-SA (8 Aug 76) 1st Ind
SUBJECT: Draft Test Design Plan (TDP) for DT II of the Biological Detector and Warning System, XM19/XM2

HQ, US Army Armament Command, Rock Island, IL 61201 17 AUG 1976

TO: Commander, US Army Test and Evaluation Command, ATTN: DRSTE-TD, Aberdeen Proving Ground, MD 21005

1. DRSAR-SA reviewed the subject TDP as requested. Our comments are forwarded as Inclosure 2.

2. In reviewing future TDP's and IEP's we request that more time be alloted for review. The IEP for the XM19/XM2 arrived here the afternoon of the suspense day. The TDP arrived here the afternoon of the 12th with an 18 August suspense date.

3. As can be seen from our comments, DRSAR-SA is concerned that the XM19 will be tested against the ACPLA threshold level stated in the ROC. DRSAR-SA considers this ACPLA too high (see comment 3). We therefore recommend that data be obtained for ACPLA's that are considerably lower than that stated in the ROC.

FOR THE COMMANDER:

1 Incl
wd incl 1
Added 1 incl
2. DA 2028

MORRIS C. JOHNSON
Acting Director
Systems Analysis Directorate

DEPARTMENT OF THE ARMY Mrs. Lee/mb/283-5222
HEADQUARTERS, U S ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MARYLAND 21005

S: 18 Aug 76

DRSTE-TD 9 AUG 1976

SUBJECT: Draft Test Design Plan (TDP) for DT II of the Biological Detector and Warning System, XM19/XM2

Commander, US Army Armament Command, ATTN: DRSAR-SA, Rock Island, IL 61202
Commander, Edgewood Arsenal, ATTN: SAREA-DE-DB, Aberdeen Proving Ground, MD 21010

1. Subject Draft TECOM Test Design Plan has been prepared by this headquarters and is provided for informal coordination.

2. Request comments/concurrence be submitted to this headquarters NLT 18 August 1976.

FOR THE COMMANDER:

1 Incl
as

WILLIAM B. McINTOSH
Director, Test Design and
Statistical Analysis Directorate

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

RECOMMENDED CHANGES TO PUBLICATIONS AND BLANK FORMS

For use of this form, see AR 310-1; the proponent agency is the US Army Adjutant General Center.

Use Part II (reverse) for Repair Parts and Special Tool Lists (RPSTL) and Supply Catalogs/Supply Manuals (SC/SM).

DATE: 17 AUG 1976

TO: (Forward to proponent of publication or form) (Include ZIP Code)
Commander
US Army Test and Evaluation Command
ATTN: DRSTE-TD
Aberdeen Proving Ground, MD 21005

FROM: (Activity and location) (Include ZIP Code)
Commander
US Army Armament Command
ATTN: DRSAR-SAM
Rock Island, IL 61201

PART I - ALL PUBLICATIONS (EXCEPT RPSTL AND SC/SM) AND BLANK FORMS

PUBLICATION/FORM NUMBER: Draft Report

DATE: August 1976

TITLE: DT II Test Design Plan for the Biological Detector and Warning System, XM19/XM2

ITEM NO.	PAGE NO.	PARAGRAPH	LINE NO.*	FIGURE NO.	TABLE NO.	RECOMMENDED CHANGES AND REASON (Exact wording of recommended change must be given)
1	6	3.2a	1&2			COMMENT: Move to Critical Issues List. REASON: We must know what the agent is after its detection so proper steps can be taken to care for casualties.
2	6					ADD: Other issues - What are laboratory requirements to support the XM2?
3	9	5.1.1a				COMMENT: DRSAR-SA reviewed the ROC. It is our opinion that if the XM19 will only meet the ROC requirements that agents with low decay rates, low ID_{50}'s, high dissemination efficiency, and at low flow rates will not be detected by the XM19. The estimated average casualties from such an agent would be 63% over an area of 10,500 square kilometers. We feel this is significant and therefore the ROC must be reviewed.
4	9	5.1.1b				COMMENT: If the number of variable organisms stated in the ROC is critical, the XM2 would not operate under the condition stated in comment 3 above. This criteria must be reviewed.
5	9	5.1.2				COMMENT: Because DRSAR-SA has doubts about the capabilities of the XM19 to detect low concentration (less than ten particles per liter with the possibility of having to worry about levels as low as 2 particles per liter). We feel that a matrix which examines the range of concentration levels the XM19 must be able to detect should be developed as part of the data required package.
6	10-11	5.1.3				COMMENT: Because of the reasons stated in 3 & 4 above this ROC should be reviewed.

*Reference to line numbers within the paragraph or subparagraph.

TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE/AUTOVON, PLUS EXTENSION	SIGNATURE
OTTO F. HAASE, JR. DRSAR-SAM Incl 2	ATV 793-3177 (53)	Otto F Haase Jr

DA FORM 1 FEB 74 2028 REPLACES DA FORM 2028, 1 DEC 68, WHICH WILL BE USED.

RECOMMENDED CHANGES TO PUBLICATIONS AND BLANK FORMS For use of this form, see AR 310-1; the proponent agency is the US Army Adjutant General Center.	Use Part II (reverse) for Repair Parts and Special Tool Lists (RPSTL) and Supply Catalogs/Supply Manuals (SC/SM).	DATE [illegible] 1976

TO: (Forward to proponent of publication or form) (Include ZIP Code)	FROM: (Activity and location) (Include ZIP Code)
Commander US Army Test and Evaluation Command ATTN: DRSTE-TD Aberdeen Proving Ground, MD 21005	Commander US Army Armament Command ATTN: DRSAR-SAM Rock Island, IL 61201

PART I - ALL PUBLICATIONS (EXCEPT RPSTL AND SC/SM) AND BLANK FORMS

PUBLICATION/FORM NUMBER	DATE	TITLE
Draft Report	August 1976	DT II Test Design Plan for the Biological Detector and Warning System, XM19/XM2

ITEM NO.	PAGE NO.	PARA-GRAPH	LINE NO.*	FIGURE NO.	TABLE NO.	RECOMMENDED CHANGES AND REASON (Exact wording of recommended change must be given)
7	11	5.1.4				COMMENT: DRSAR-SA questions the ROC. Therefore we would like to be sure the data obtained can determine the sensitivity of response time to concentration far less than those indicated in the ROC

*Reference to line numbers within the paragraph or subparagraph.

TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE/AUTOVON, PLUS EXTENSION	SIGNATURE
OTTO F. HAASE, JR. DRSAR-SAM	ATV 793-3177 54	Otto F Haase

DA FORM 1 FEB 74 2028 REPLACES DA FORM 2028, 1 DEC 68, WHICH WILL BE USED.

155MM CANNON LAUNCHED GUIDED PROJECTILE (CLGP)

OPERATIONAL ANALYSIS

Next page is blank.

DRSAR-SAM (11 Aug 76)
SUBJECT: 155mm Cannon Launched Guided Projectile (CLGP) Operational Analysis

TO DRCPM-CAWS-TM FROM DRSAR-SA DATE 2 3 AUG 1976 CMT 2
Mr. Schlenker/cl/5075

1. References:

a. GAO Information Request to COPPERHEAD Project Office (GAO Review 951283), 11 Aug 76, subject as above.

b. Answers to Questions in GAO Review 951283, 19 Aug 76 (Incl 2).

2. As requested, DRSAR-SA has prepared a set of answers to the GAO Information Request, reference 1a.

3. In preparing reference 1b, DRSAR-SA was required to infer the purpose of the GAO in asking the question so as to clarify terms such as "minimum and maximum required range." Additionally, it does not seem to be proper for DRSAR-SA to speak for the entire Army -- User and Developer -- on such issues as the need for a MULE-type designator (Question number 8 of reference 1a). Therefore, the answers given to all these questions reflect only the technical and operational requirements of the CLCP program, as we understand them.

SIGNED

MORRIS C. JOHNSON
Acting Director
Systems Analysis Directorate

2 Incl
Added 1 incl
2. Answers to Questions

REGRADED UNCLASSIFIED WHEN SEPARATED
FROM CLASSIFIED INCLOSURES

DISPOSITION FORM

For use of this form, see AR 340-15, the proponent agency is TAGCEN.

S-20 Aug 76

REFERENCE OR OFFICE SYMBOL	SUBJECT
DRCPM-CAWS-TM	155mm Cannon Launched Guided Projectile (CLGP) Operational Analysis

TO DRSAR-SA FROM DRCPM-CAWS-TM DATE 11 Aug 76 CMT 1

Mr. Fuqua/jc/6534

1. The GAO is reviewing the 155mm CLGP program. They have provided the attached information request (Incl 1) to our Field Office located at MICOM. Based on your operational studies and analysis that your division has performed on CLGP, request answers be provided to the questions that are circled. Even though some of the questions should be answered by the user, ARMCOM is in a better position to reply.

2. Reply is desired by 20 Aug 76.

J. Clifford Fuqua

1 Incl
as

J. CLIFFORD FUQUA
Acting Chief, Technical Mgt Division

DA FORM 2496 REPLACES DD FORM 96, WHICH IS OBSOLETE. ☆GPO-1975-665-422/1063

GAO Information Request to COPPERHEAD Project Office (GAO Review 951283)

Currently, there are three ground designators under development - the LWLD, MULE and GLLD. Each designator has different characteristics such as range, beam divergence, and tracking accuracy. The purpose of the request is to identify the designator characteristics required by COPPERHEAD and to identify the impact of differing designator characteristics on COPPERHEAD performance. This information will be used in assessing the need for three ground designators.

Range requirements and operational (tactical) requirements:

1. What are the minimum and maximum ground designator-to-moving target ranges required by COPPERHEAD?

2. Why is the minimum range set at that value?

3. Why is the maximum range set at that value?

4. What are the minimum and maximum ground designator-to-stationary target ranges required by COPPERHEAD and why are they set at these values?

5. What is the operational concept for employment of COPPERHEAD in terms of ground designator-to-target range, COPPERHEAD-to-target range, and HELLFIRE-to-ground designator range?

What is the operational concept as to the location of the designator, ~~HELLFIRE~~ and target with respect to the FEBA?

6. What studies, analyses, field tests, etc., have been done on the frequency of opportunities for engagement at various ground designation ranges? What were the results?

7. What are the advantages and disadvantages to ~~HELLFIRE~~ copperhead of the additional range provided by GLLD over the range provided by MULE?

8. What would be the effects on ~~HELLFIRE~~ copperhead operational performance and cost effectiveness if the GLLD program were terminated and replaced by the MULE?

Why does the Army not have a requirement for a MULE type designator?

10. What percentage of ~~HELLFIRE~~ copperhead designations are expected to be from ground designators?

Beam Divergence and tracking accuracy requirements:

1. How are ~~HELLFIRE~~ copperhead's designator requirements stated:

a. In terms of the amount of energy and time of energy on target.

b. In terms of beam divergence and tracking accuracy at various designator-to-target ranges.

c. Both 1a and 1b.

Incl 1

2. What are the values of these requirements in question 1 above? (If the requirements are stated as in 1a, identify the values here and convert them into values as stated in 1b, and display in the following format:)

Range (m)	Beam Divergence (mr)		Tracking Accuracy (mils)	
Designator to Target 1/	Minimum 2/	Maximum 3/	Minimum 4/	Maximum 5/
1000				
1500				
2000				
2500				
3000				
3000				
3500				
4000				
4500				
5000				

1/ If beam divergence and tracking accuracy requirements are different for stationary and moving targets, prepare two separate charts.

2/ Minimum (smallest) beam divergence required.

3/ Maximum (largest) beam divergency required (acceptable).

4/ Minimum (smallest) tracking error required.

5/ Maximum (largest) tracking error required (acceptable).

3. At what ranges does the MULE satisfy ~~HELLFIRE~~ copperhead beam divergency and tracking accuracy requirements? At what ranges does the MULE not satisfy these requirements?

4. At what ranges does the GLLD satisfy ~~HELLFIRE~~ Copperhead beam divergency and tracking accuracy requirements? At what ranges does the GLLD not satisfy these requirements?

OTHER REQUIREMENTS:

1. What other designator characteristics are required by ~~HELLFIRE?~~ copperhead: (e.g., duty cycle, activation time, etc.)

2. Which characteristics are met by both MULE and GLLD?

3. Which characteristics are met by GLLD but not MULE?

4. Which characteristics are met by MULE but not GLLD?

5. Which characteristics are met by neither MULE or GLLD?

OTHER QUESTIONS:

1. In an October 14, 1975 letter to the AMRAD committee, the Naval Weapons Center said, "There is no Army stated need which the MULE could not completely fulfill." In a November 6, 1975 letter to the Marine Corps Development Center, the Precision Laser Designator Office said, "... the MULE will not meet the CLGP or HELLFIRE designation requirements." What is COPPERHEAD's position on this matter and why?

2. What interest has the Marine Corps expressed in using COPPERHEAD? Does the Marine Corps plan to use it with MULE?

If you have any questions, please call Bill Noel at 876-7226.

Answers to Questions from GAO to COPPERHEAD (CLGP) Project Office
(GAO Review 951283)

1. The minimum designation range required for designation of all ground targets is zero, i.e., the ground designator should be able to approach arbitrarily close to the target he is designating. As required by the CLGP system specification, the maximum range for ground designation of moving targets is 3 km and for stationary targets is 5 km.

2. These specified minimum and maximum range limits define the conditions within which guidance error may not exceed the specified value ________.*

3. The designation range (DR) limits are a reflection of both technical and tactical factors. It is not suggested or implied that 3 km is the maximum tactically useful DR or that the likelihood of target defeat is negligible beyond that range. The specified values are a practical limit for test purposes and indicate the performance capability of the system at military useful ranges.

4. The maximum specified designation range (DR) of stationary targets is 5 km. Tactically, ranges in excess of 5 km are regarded as unlikely for ground designators because of the difficulty of acquiring targets at that range, given intervisibility, and because surface to surface intervisibility is improbable beyond 5 km.

5. The operational concept for employing COPPERHEAD places the artillery batteries in their conventional positions relative to FEBA. In the case of the M109A1 and that of the XM198 howitzers, battery position is approximately 6 km aft of FEBA. With each direct-support (DS) battery will be associated three (3) forward observers (FOs) equipped with the GLLD and possibly one or more FOs from higher artillery echelons, e.g., from attached DS reinforcing batteries or from general-support (GS) artillery units. Mortar FOs may also be equipped with laser designators to provide additional designator capability for both COPPERHEAD and HELLFIRE. Generally, the FO parties will occupy elevated, tactically sound, bunkered positions at or near FEBA during defensive operations. Some FO parties may be deployed defensively with advanced guard outposts 1 to 2 km ahead of FEBA. Although doctrine for employing FOs has not been firmly established, some consideration has been given to placing CLGP FOs in other positions relative to FEBA such as with reconnaissance parties in an attack posture. In the above locations, designators may acquire targets as far as 5 km from their own position or about 7 km from FEBA, while in a prepared defense. Doctrinarily FOs will continue to designate moving targets as they approach FEBA until final protective fires are required, i.e., between 0.5 to 1 km from FEBA. Being elements of the artillery system, GLLD-equipped FOs will give priority to COPPERHEAD missions when faced

*Classified data has been deleted.

Incl 2

with a high density of armored targets. If artillery fires are unavailable or infeasible for a given mission, an FO party with the GLLD may designate remotely for HELLFIRE. For the security of the helicopter launching HELLFIRE, the helicopter will not generally approach within three kilometers of a group of targets having an organic air defense capability, such as the Soviet ZSU-23-4. However, in the designator-remote mode for HELLFIRE, ground designators may be anywhere from 0.5 to 5 km from the target.

6. During conduct of the Cost and Operational Effectiveness Analysis for COPPERHEAD (CLGP COEA) the average range from FEBA at which moving targets were designated and defeated by CLGP in the OSM computer model was recorded. Under poor visibility conditions, results depended strongly upon the meterological visibility range and to a lesser extent on the FO engagement procedures employed. For visibility ranges in excess of 10 km, however, the mean range from FEBA for targets defeated by CLGP fell within the interval 2700-3000m for a variety of other parameter values. Using a similar scenario within OSM but with the current version of CLGP, recent studies show an average range of engagement of approximately 2700m and of range from FO to target at kill of 2500m. The corresponding average acquisition range by the FO party was about 3500m.

There are presently only two field simulations that relate to CLGP operations. These are referred to as (a) FOTOGLLD and (b) HELBAT 4. FOTOGLLD was performed by MASSTER at Ft Hood, TX in the autumn of 1974 using a reinforced armored company maneuver force attacking a prepared defensive position occupied by (among others) a GLLD-equipped FO party. This was primarily a test of the CLGP communications, command, and control concept in which firings were only simulated. However, target acquisition, request for fire and designator tracking were tested. The acquisition typically occurred between ________.* Targets were engaged sequentially as the attacking force advanced. The engagement of targets by CLGP FOs was broken off at a range of approximately 1 km, after which it was presumed final protective fires would commence. This test indicated that preplanned fire using existing fire control equipment is feasible.

The HELBAT 4 test[1] was conducted jointly by the Human Engineering Labs and the US Army Field Artillery School (USAFAS). The test took place in the autumn of 1973, at USAFAS, Ft. Sill, OK. During the part of the test pertinent to CLGP operations, single, moving tank targets were acquired and engaged by a single GLLD-equipped FO party. Acquisition,

---

[1] Horley, G. L. and Dousa, W. J., Jr. HELBAT 4 - Automated Fire Direction on Moving Targets, Human Engr Labs Battalion Arty Tests, Tech Memo 19-72 (CONF), U.S. HEL, Aberdeen P.G., MD, May 1976.

*Classified data has been deleted.

limited often by atmospheric conditions and terrain typically occurred at about 3 km (max 5 km; min 2.5 km). The single target was located at two points along its path by the laser rangefinder and these data automatically sent to a computer at the fire direction center (FDC) which calculated an intercept point and firing data and transmitted the gun orders to the firing unit which actually fired the mission using frangible, ballistic ammunition. This test demonstrated the feasibility of an automated fire control (F/C) system with direct GLLD input to the F/C computer. At projectile impact the mean distance between projectile and target was less than ____.*

7. The principal advantage of employing COPPERHEAD (CLGP) instead of direct-fire, antiarmor guided projectiles such as TOW is the ability to engage and defeat a high density of armored targets at ranges in excess of 3 km. To engage targets at such ranges with a laser guided projectile requires an extremely precise designator such as the GLLD or equivalent. Guidance accuracy under these conditions is predominantly dependent upon the laser spot jitter at the target created during tracking. A less precise designator than the GLLD, such as the MULE, would produce greater guidance errors at a given designation range or, alternatively, require the designator to stay closer to the target he is designating for the same guidance error, thus increasing the risk of counterfire to himself. When precision designators such as GLLD or ATAFCS are employed targets are attrited at a greater range from the friendly maneuver elements, enhancing their survivability. For all of these reasons it is advantageous to use GLLD (or ATAFCS) rather than MULE.

8. To our knowledge no deep operational analyses has been performed in which the COPPERHEAD system was mated with the MULE designator. Consequently, it is impossible to precisely quantify the system effectiveness decrement that would be incurred in using MULE rather than GLLD. Similarly, a cost-effectiveness analysis of MULE versus GLLD in connection with COPPERHEAD remains to be done.

9. The specifications for GLLD in terms of laser power, duty cycle, beam divergence, and tracking error were driven by the need for high accuracy at extended designation range (3-5 km) with both COPPERHEAD and HELLFIRE. This requirement is consistent with the use concept described above. Since the MULE does not meet the specifications for the GLLD (or ATAFCS), the Army has no requirement for MULE.

10.1 The COPPERHEAD requirements for designation are identical to those detailed in the GLLD system specification.

10.2 The COPPERHEAD accuracy requirement can be achieved over its operational envelope when used with a designator having the characteristics of the developmental GLLD used in the OT 1 tracking tests.

---

*Classified data has been deleted.

NOTE: The asterisks(*) appearing in these answers denote deletion of CONFIDENTIAL data. Authorized personnel may request this information from Commander, US Army Armament Command, ATTN: DRSAR-SA, Rock Island, IL 61201

DISTRIBUTION LIST

Copy No.	
	Commander
	US Army Materiel Development and Readiness Command
1	ATTN: DRCMA
2	DRCRD
3	DRCPA-S
	5001 Eisenhower Avenue
	Alexandria, VA 22333
	Commander
	US Army Armament Command
4	ATTN: DRSAR-CG
5	DRSAR-DCG
6	DRSAR-EN
7	DRSAR-RD
8	DRSAR-CP
9-40	DRSAR-SA
41	DRSAR-PA
42	DRSAR-PP
43	DRSAR-OP
44	DRSAR-QA
45	DRSAR-IS
46	DRSAR-MM
47	DRSAR-MA
48	DRSAR-AS
49	DRSAR-SF
	Rock Island, IL 61201
50	Commander
	US Army Test and Evaluation Command
	ATTN: DRSTE-SY
	Aberdeen Proving Ground, MD 21005
51	Commander
	US Army Electronics Command
	ATTN: DRSEL-SA
	Fort Monmouth, NJ 07703
52	Commander
	US Army Missile Command
	ATTN: DRSMI-CS
	Redstone Arsenal, AL 35809
53	Commander
	US Army Tank-Automotive Materiel & Readiness Command
	ATTN: DRSTA-S
	WARREN, MI 48090

DISTRIBUTION LIST (Cont)

Copy No.	
54	Commander US Army Tank-Automotive Research & Development Command ATTN: DRDTA-V Warren, MI 48090
55	Commander HQ, US Army Aviation Systems Command ATTN: DRSAV-D P. O. Box 209, Main Office St. Louis, MO 64502
56	Commander US Army Troop Support Command ATTN: DRSTS-G St. Louis, MO 63120
57	Project Manager for Cannon Artillery Weapons Systems ATTN: DRCPM-CAWS Dover, NJ 07801
58	Commander US Army Development and Readiness Command Office of the Project Manager for Selected Ammunition ATTN: DRCPM-SA Dover, NJ 07801
59	Project Manager for M110E2 ATTN: DRCPM-M110E2 Rock Island, IL 61201
60	Project Manager for Air Defense Gun Systems ATTN: DRCPM-ARGADS Rock Island, IL 61201
61	Product Manager for Production Base Modification & Expansion ATTN: DRCPM-PBM Dover, NJ 07801
62	Product Manager for Advanced Attack Helicopter Systems US Army Aviation Systems Command St. Louis, MO 63166
63	Product Manager for AH-1 Cobra Series Aircraft US Army Development & Readiness Command P. O. Box 209 St. Louis, MO 63166

DISTRIBUTION LIST (Cont)

Copy No.	
	Commander Rock Island Arsenal
64	ATTN: SARRI-CO
65	SARRI-L
66	SARRI-LPL Rock Island, IL 61201
67	Commander Watervliet Arsenal ATTN: SARWV-CO Watervliet, NY 12189
68	Commander Pictainny Arsenal ATTN: SARPA-PA-S Dover, NJ 07801
69	Commander Edgewood Arsenal ATTN: SAREA-DE-N Aberdeen Proving Ground, MD 21010
70	Commander Frankford Arsenal ATTN: SARFA-PA Philadelphia, PA 19137
71	Commander Human Engineering Laboratories ATTN: DRXHE-D Aberdeen Proving Ground, MD 21005
72	Commander US Army Materiel Systems Analysis Activity ATTN: DRXSY-D Aberdeen Proving Ground, MD 21005
73	Commandant US Army Field Artillery Center Fort Sill, OK 73503
74	Commandant US Army Infantry School Fort Benning, GA 31905
75	Commander US Army Missile & Munitions Center & School Redstone Arsenal, AL 35809

DISTRIBUTION LIST (Cont)

Copy No.	
76	Commandant US Army Air Defense School Fort Bliss, TX 79916
77	Director US Army Management Engineering Training Agency ATTN: AMXOM-AMS Rock Island, IL 61201
78	Commander US Army TRADOC Systems Analysis Activity White Sands Missile Range White Sands, New Mexico 88002
79	Director Advanced Research Projects Agency 1400 Wilson Boulevard Arlington, VA 22209
80	Commander Defense Logistics Studies Information Exchange Fort Lee, VA 23801
81	Commander US Army Logistics Management Center ATTN: AMXMC-LS Fort Lee, VA 23801
82	Commander US Army Logistics Center ATTN: ATCL-S Fort Lee, VA 23801
83-94	Defense Documentation Center Cameron Station Alexandria, VA 22314